Crystal Radios for the Shortwave Bands

(21 Jan 02)

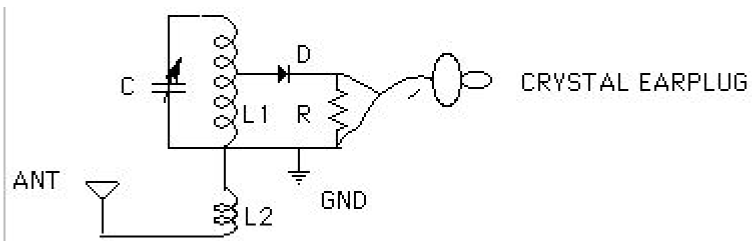
The first set tunes from about 5.8 to 14 MHz, which includes the 49, 41, 31, 25 and 22 meter shortwave broadcast bands. The capacitor is the oscillator section of a poly film variable capacitor, and the coil is wound on a toilet paper core. The main coil, L1, was wound on a length of 1/2 inch of the core, and separated from the antenna coupling coil, L2, by about 1/8 to 1/4 inch on the same core. Calculated inductance of L1 was 10.6 uH. Measured capacitance of the variable was 10 - 68 pF. Using a 50 foot end fed antenna, stations could be heard 24 hours a day, with the higher bands being heard during daylight, and the two lower bands coming in at night as well.

There are 4 primary ways to attach antenna and ground, and all work to one degree or another. First and second, the antenna alone may be connected to either the antenna tap or to the ground tap. Third and fourth, the antenna and ground are connected to the normal taps as indicated, or they may be reversed. A small frequency shift was noted when going from option 3 to 4. Use of the ground sometimes made the signals stronger. Quantitative assessments using on-air stations was not attempted as the signal strength varied constantly, with shifts of up to 10 dB being noted within the space of 30 seconds. As a side note, just connecting the antenna to the top of the tank coil was not as productive.

Selectivity, while not great, was sufficient to separate the short-wave BC bands (the 25 and 22 meter bands tended to run together, however), and often to separate two stations within a band. Slow tuning, even with this selectivity, is needed due to changing signal strengths and because of the fast tuning rate.

Using a longer antenna gave higher signal strengths, as expected, and little or no shift in frequency was noted when going from one antenna to the other. No MW broadcast band interference was observed.

This is a schematic of the set:



C - 10-60 pF
L1 - 14 turns #24 plastic coated wire on 1 5/8 inch core tapped at 8th turn from top for detector
L2 - 5 turns wound 1/8 inch below L1 on same core
D - 1N34A diode
R - 47 kohm

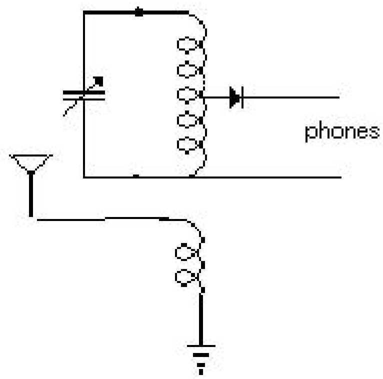
Spacing between L1 and L2 was closer to 1/4 inch, as it turned out when my students built this, and they seemed okay. Since the shoddy antenna I have in my classroom is well shielded by the metal roof of the building, I used a grid dip oscillator to check the sets for response before letting them out of the room. With the unmodulated signal from the GDO, I could hear a few faint heterodyne squeals from stations that were there but too weak to hear.

I made another coil on the same diameter form using #20 solid plastic coated hookup wire, winding 20 turns on 2 inches for L1 and 6 turns for L2. This gave me slightly stronger signals, as expected. I made a breadboard attempt to use this with a Tuggle antenna tuner, but gave up early on, primarily since this was designed to be a student radio, and for other more technical reasons which I'll explain below.

This is really a "first iteration" radio, designed just for shortwave use, and, while it works pretty well, clearly has some way to go. The tuning rate, some 10 MHz in a 180 degree rotation of the tuning knob, is way too fast, but is probably okay for this first attempt. It was clear that the selectivity of the set leaves something to be desired, so more work on the coils is in order. I didn't spend much time optimizing the coil tap for the detector, just picking one that is historically useful. Tapping the detector to the top of the tank circuit was not as productive as the tap I used. I also didn't spend any time picking over detectors, and just grabbed the first germanium diode out of the box. If I can get the selectivity up a bit, I will have to get serious about band

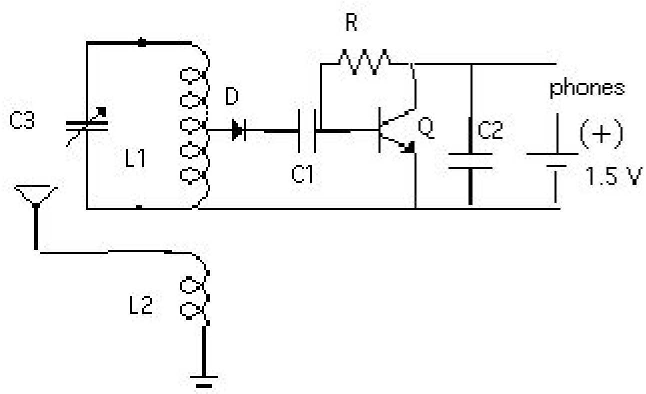
spreading the tuning. Obviously, I need to go back and look at an antenna tuner again. One thing I realized, which may or may not make a difference, is that at these frequencies the antenna is a quarter wavelength long or longer, so you can't make it resonant with just a few turns of a coil in the antenna line. However, the set is a snap to build (especially the coil), and picks up a bunch of stations, and is fun to use if you haven't tried the higher frequencies.

Okay, time to do some more playing around. Variation #2 was built to try to get some more selectivity for a kid radio, and essentially the same as the first but with the primary separated from the tank coil. This seemed to work a bit better, and the bands separated better as well. This is the schematic with some notes:



For this one, I wound the coils on a 1 5/8 inch toilet paper core, and used 15 close wound turns for the tank coil, tapped at turn 6 from the ground for the detector. The primary coil was 6 turns separated by 1/4 inch from the secondary. If you want to dispense with phones, one of the little Radio Shack audio amps works fine. With the amp, I noticed that with my 150 foot long wire, the top of the BC band came in the background a little; not so with the 50 foot "student" antenna. The diode was a germanium out of the junk box, and the variable capacitor was the 10 - 70 pF oscillator section of a poly film rf tuner capacitor. The wire was #24 plastic coated telephone wire, which gives about 30 turns per inch. It tunes from the 49 meter band to just into the 19 meter band. It all fit nicely on a 4 inch length of 1 inch x 4 inch pine.

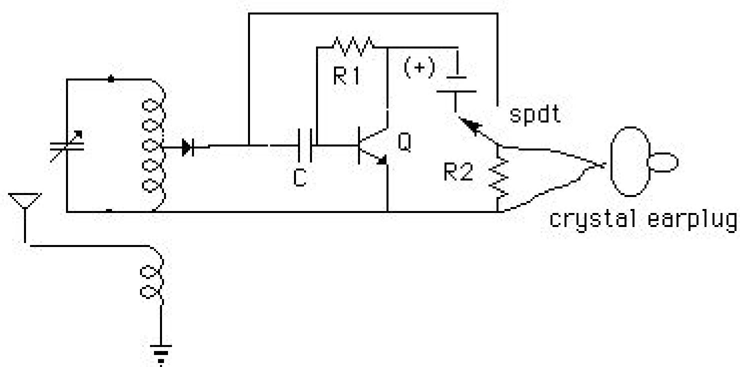
Since my 8 year old seemed interested in doing something with a crystal set for a science project, we made up this next one, really just a slight modification of the one above, adding an audion type headphone amp to drive a low impedance set of phones (he ended up taking my Stromberg Carlson sound powered set, declaring them the most comfortable). This is the schematic of the finished product:



C3, L1, L2, and D are as described above.
C1, C2 are 0.1 uF disc ceramics
R = 100 kohms
Q is a 2N2222, but just about any similar transistor will do. Reverse the battery if using a PNP transistor.

I was pretty lavish with this one, and used a 7 inch section of 1 x 4 inch pine for the base, and even added a panel to support the variable and a simple paper dial that I "calibrated" for the shortwave bands using a dip meter. With the sound powered phones, I probably should have gone on and made the coupling between L1 and L2 variable to (1) control the volume on the stronger stations and (2) to try and improve the selectivity, which isn't bad, but isn't great either.

And now (Drum roll), a shortwave convertible. Actually, this should look very familiar, since I use this basic one transistor amp a lot.
This amp was added to use higher impedance phones, such as the standard 2k, or the crystal earplug with the parallel resistor.



Q - just about any general purpose transistor will do, such as a 2N2222 or whatever you have on hand. I used a PNP out of a Radio Shack pack 15 on one set(and reversed the battery); worked fine.
R1 - 470 kohms
R2 - 47 kohms
C - 0.1 uF - you can probably use just about anything here
The battery I used was a 1.5V AA, but a 9 V worked fine too with a little more volume.
The crystal radio portion of the set is as described above. I used brass coated thumbtacks stuck into a piece of pine for soldering points. You can put in a couple of fahnestock clips where R2 and the crystal earplug go and use any phones you have on hand. I designed this to be an easy-to-assemble kid radio, but you can get as fancy as you like. I just used hot glue to hold the battery holder and switch down on the base. You might notice that, unlike the original crystal convertible, I don't disconnect the diode from the input capacitor C when switching from straight crystal to amplified crystal. Found that it didn't seem to matter, and made wiring easier. Also note that the battery connects after the phones, with the phones going to chassis ground, unlike the set I made with the audion type amp. You have some flexibility here, so do what suits you, but this arrangement gives you the easy convertible switch.

So how does it do? As built, the amplifier seems to give about a 10 to 20 dB boost to the signal. Makes for more comfortable listening, and stations that you can tell are there become clearly audible. Going from a 50 foot antenna out the window to a 6 foot whip indoors, I was still able to hear a few stations, even in the daytime. I tried adding a feedback coil for a little regeneration, just for grins. Alas, the used 1.5 V AA wasn't having any of this, so I'll try it another day.

For more information on the general nature of shortwave listening and the frequencies for each band, try this web site:
http://www.danatkinson.co.uk/html/sw/faq.htm

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